LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

PROCEEDINGS OF THE UNITED STATES NATIONAL MUSEUM

issued by the

SMITHSONIAN INSTITUTION
U. S. NATIONAL MUSEUM

Vol. 96 Washington: 1946 No. 3204

A REVISION OF THE GENERA OF MULLETS, FISHES OF THE FAMILY MUGILIDAE, WITH DESCRIPTIONS OF THREE NEW GENERA

By LEONARD P. SCHULTZ

DURING my recent studies of the mullets of Venezuela I became interested in the generic relationships of the Mugilidae and attempted to define the genera of this group of fishes. To accomplish this I examined specimens of the mugilid species that have been made genotypes, basing my diagnoses on specimens in the United States National Museum. The numerous genera of the family have not been well defined, and I failed to locate any key or contribution in which all the genera of the world were compared. This study is a provisional one. Much more work needs to be done before the various genera are thoroughly understood, especially in regard to those centering around *Mugil* and *Chelon* as herein defined. My conclusions were made after several hundred specimens from most parts of the world were examined; the material used is summarized under each genus. No attempt is made to place under each genus all the species that may belong there, since that task would require the reexamination of the types of all described species, scattered in museums throughout the world.

Several ichthyologists have studied the Mugilidae, presenting in keys or diagnoses their understanding of certain genera. Among the recent ones may be mentioned Jordan and Evermann (U. S. Nat. Mus. Bull. 47, pt. 1, p. 809, 1896); Oshima (Ann. Carnegie Mus., vol. 13, p. 241, 1922); Weber and de Beaufort (The Fishes of the Indo-Australian Archipelago, vol. 4, p. 230, 1922); Mohr (Zool. Jahrb., vol. 54, pp. 195–200, 1927); and Roxas (Philippine Journ. Sci., vol. 54, No. 3, pp. 393–396, 1934). Dr. J. L. B. Smith (Ann.

South African Mus., vol. 30, pp. 587–589, 1935) has reviewed in an excellent manner the problems concerning the confusion in regard to African mugilid species and their diagnoses, but he did not attempt to solve the problem as to what genera are valid. His discussion of characters used in describing mullets is worthy of considerable thought, inasmuch as it applies in general to generic descriptions.

Despite the large amount of material examined, I have experienced great difficulty in arranging the species of Mugilidae into genera of concise and of clear definition, owing mostly to the paucity of useful taxonomic characters and somewhat to the inadequate descriptions that abound in the literature. Nevertheless, I have constructed a key to the genera that is practical, though artificial in itself, and that I believe defines the natural generic units as observed.

The type of *Agonostomus bryanti* Bean and Weed, which I have examined, belongs to the genus *Hypseleotris* Gill in the family Eleotridae. It is not a mullet.

The family Mugilidae as recognized by authors is remarkably constant in anatomical structures as far as investigated by me; the number of vertebrae is usually 24 or 25, with 11 to 13 abdominal and 11 to 13 caudal. The relative positions of the fins are uniform, and there is no outstanding example of a great increase in number of fin rays in any genus. Among other characters the shape of body, with depressed head anteriorly, spiny preorbital, broad scaly interorbital, large scales on head and body, two dorsal fins well separated, the first with peculiarly arranged spines, are characteristic of all mullets.

Among the characters studied it appears that the mouth parts of mugilid fishes have evolved and specialized, whereas the other anatomical structures have remained more or less constant for most of the genera. Therefore, I have studied the preorbital, nostrils, teeth, jaws, and other mouth parts rather carefully in search of characters suitable for defining and recognizing mugilid genera. In most genera the teeth remain fairly constant in structure at all sizes beyond the very immature, but in *Mugil* there is evidence that some of the tips are simple in the young, becoming bifid or even trifid in very large adults. It is a well-established fact, also, that in certain species young mullets have two anal spines, but half grown and adults have three anal spines. Recent American authors refer to the immature stage of the mullet with two anal spines as the "querimana stage." The adipose eyelid is another character that develops with age, usually appearing at standard lengths of 30 to 50 mm. and reaching the highest development in the adults, or else being absent at all ages.

The key that follows is based on specimens of 40 mm. and over, but one should be able by it to identify mullets to genera at lengths of half that or shorter. It is a preliminary step in the definition of mugilid genera, based on the genotypes and other species referred to the genera recognized.

1a. Ventral side of mandible with 4 bluntly rounded fleshy lobes, free posteriorly; two strips of transverse, close-set, membranous lamellae along lateral edge of lower jaw on each side externally; mandible bluntly pointed; lower jaw included, without teeth; upper jaw with a narrow band of villiform teeth; nostrils close together; no adipose eyelid; upper lip forming tip of snout; scales ctenoid (fresh and brackish waters of western tropical Pacific).

Cestraeus Valenciennes

1b. Mandible without the 4 fleshy lobes and lamellae as described above.

2a. Upper lip not forming anterior tip of head; snout fleshy, bluntly rounded, forming anterior tip of head, snout projecting in front of upper lip, the latter narrow, inferior in position; lower jaw included; no adipose eyelid; scales ctenoid.

3a. Upper jaw with a band of incisorlike multicuspid teeth inside of thick lips; each side of lower jaw with a patch of multicuspid teeth widely separated at symphysis; nostrils very close together in front of eye; margin of lower jaw rounded, lower lips thick; no symphyseal knob at middle of lower jaw and no notch in middle of upper lip; scales ctenoid (fresh waters of Central America, Mexico, and Cuba)_____**Joturus** Poey

3b. Upper and lower jaws with fine teeth in a single row in each jaw, tips simple, none of the teeth with bifid or multicuspid tips; nostrils at side of head at lower level of orbit, widely spaced, the posterior closer to eye than to anterior nostril; margin of lower jaw angular, not rounded, with a symphyseal knob and upper lip with pit to receive it; maxillary and premaxillary not hooked downward, lower lip thin-edged, teeth in both jaws ciliform, posterior edge of preorbital very narrow, and anterior edge nearly straight, not with a concavity; scales ctenoid (fresh waters, rarely in brackish water, India)_____**Rhinomugil** Gill

2b. Upper lip forming anterior tip of head and not inferior in position below a projecting fleshy snout.

4a. Upper and lower jaws with thick lips, a distinct wide band of teeth inside of lips, but no teeth on margin of lips; lower lip not directed or folded downward; tips of teeth of inner rows on upper jaw bifid or trifid, those on lower jaw simple or bifid; anterior margin of lower jaw broadly rounded; maxillary reaching past front of orbit and past posterior tip of preorbital bone; lower lip thick, not thin at edge and not bearing teeth; no adipose eyelid; nostrils close together; scales ctenoid (fresh waters, tropical New World westward to Hawaiian Islands and Mauritius, New Zealand, and New South Wales).

Agonostomus Bennett

4b. Teeth and lips not as in *4a.*

5a. Lower lip thick-edged, without thin edge and not directed forward horizontally but folded or directed downward so that lower lip fits more or less snugly behind upper lip when mouth is closed; margin of lower jaw angular.

6a. Lower lip bearing setiform teeth externally on edges, these arranged in a narrow or wide band.

7a. Both lips with broad edges bearing externally a band of minute teeth in several close-set rows, most of teeth having bifid tips; lower lip directed but not folded downward and without free inner edge; teeth minute, slender, with bifid tips, arranged in numerous close-set rows on upper pharyngeals; nostrils very close together; no adipose eyelid; rear end of preorbital bone

several times wider than space between nostrils; scales ctenoid (marine, in Pacific Ocean of tropical New World).

Chaenomugil Gill

7b. Both lips with narrow edges bearing externally a narrow band of setiform teeth in 2 or 3 rows; lower lip folded downward and largely free along its inner edge.

8a. Margin of lips of both jaws with characteristic 3-pointed setiform teeth set in 2 or 3 rows; adipose eyelid obsolete or undeveloped; nostrils moderately separated, much closer together than anterior is from edge of snout, lip excluded; maxillary not reaching past rear edge of preorbital bone; scales cycloid (marine, Oceania)---- **Neomyxus** Steindachner

8b. Margins of both lips with a uniserial row (occasionally a few in an outer or second row) of setiform teeth with unbranched curved tips; adipose eyelid well developed (except nearly absent in young) in adults, reaching almost to pupil; nostrils, about as far apart as anterior is from edge of snout, lip excluded; scales cycloid (marine, Galápagos Islands).

Xenomugil, new genus

6b. Lower lip bearing several rows of fleshy papillae, both externally and internally, with their tips crenulate, becoming more so in adults a foot long or longer; upper lip very broad, bearing papillae, the crenulate edge continuous around rictus with crenulate lower lip; nostrils close together, the anterior one as close to premaxillary groove as to posterior nostril; front edge of preorbital with an angular or concave notch; premaxillary and maxillary bent downward posteriorly but tip of maxillary not exposed as in *Chelon;* adipose eyelid undeveloped or absent; scales cycloid (marine, Oceania and Indian Ocean)---------- **Crenimugil,** new genus

5b. Lower lip with a thin edge, directed horizontally forward or nearly so, not folded downward and not bearing teeth externally on lips although fine teeth may occur along edge of lip; upper lip with a band of teeth or with a uniserial row of setiform or ciliform, or small incisorlike teeth, sometimes more or less firmly set.

9a. Adipose eyelid well developed, reaching to or nearly to pupil except on young 50 mm. in standard length or shorter, in which case posterior edge of preorbital narrower than space between nostrils; distance between nostrils wide, equal to or greater than width of upper lip; anterior and posterior nostrils widely separated, farther apart than anterior nostril is from groove that separates upper lip from rest of snout; posterior edge of preobital narrower (fig. 28, *a-c*) than distance between nostrils and its posterior tip scarcely or not reaching past front of eye; maxillary and premaxillary not hooked downward and maxillary not notably exposed; maxillary and premaxillary in line with front edge of preorbital; no teeth on vomer or palatines; scales cycloid (marine, along coasts of Europe, Africa, Asia, North and South America, West Indies, Oceania to Red Sea, islands of Atlantic and Pacific Oceans in temperate and tropical waters)------ **Mugil** Linnaeus

9b. No adipose eyelid; distance between nostrils narrow, contained 2 or more times in width of upper lip; anterior nostril much closer to posterior nostril than anterior is from groove that separates upper lip from rest of snout; width of posterior edge of preorbital wider than distance between nostrils.

10a. Teeth setiform or ciliform, in upper lip with simple undivided tips.

11a. Teeth numerous in upper jaw in a single row, with simple tips rather coarse and incisorlike, firmly set, not ciliform, and not forming part of upper lip, but exposed; anterior edge of preorbital straight or nearly so; maxillary nearly straight, not notably exposed or hooked downward over the premaxillary (fig. 29, *a-c*) and not extending past rear edge of preorbital bone; premaxillary with its anterior margin evenly curved, the nondentate posterior part in line with toothed portion, not at sharp angle to it; narrow band of teeth on vomer and palatines; scales cycloid (marine and fresh waters, Australian region and tropical western Pacific)---------- **Myxus** Günther

11b. Teeth in upper jaw ciliform, flexible, extremely fine and numerous, forming part of upper lip.

12a. Anterior edge of preorbital concave or angular; maxillary with its posterior part notably exposed, sharply curved downward over posterior part of premaxillary (fig. 30, *a–d*) and extending below preorbital a distance greater than width between nostrils; premaxillary with its front margin sharply angular, nondentate posterior portion hooked backward and downward almost at right angles to toothed portion; villiform patches of teeth on vomer and palatines present or absent; scales cycloid (marine, tropical and temperate Atlantic, Pacific, and Indian Oceans of Old World, not yet found in New World). **Chelon** Röse

12b. Anterior margin of preorbital evenly curved or nearly straight (fig. 31, *a–c*); maxillary with its posterior part somewhat exposed but in line with posterior part of premaxillary and not curved downward, but ending about opposite posterior edge of preorbital; premaxillary with its front margin evenly curved; a narrow band of villiform teeth present on vomer and palatines; scales ctenoid (fresh waters, possibly brackish too, Australia, Burma, and South Africa)------ **Trachystoma** Ogilby

10b. Teeth in upper lip setiform rather firmly set, with trifid or bifid tips; teeth in lower jaw ciliform and embedded more or less in thin edged lower lip; anterior edge of preorbital concave; maxillary with its posterior part notably exposed, sharply curved downward over posterior part of premaxillary and extending below preorbital a distance greater than width between nostrils; premaxillary with its front margin sharply angular, nondentate posterior portion hooked backward and downward at a sharp angle; villiform patches of teeth on vomer and palatines; scales cycloid (marine, South Africa). **Heteromugil,** new genus

In speculating on the relationships among the genera of Mugilidae, I should assume that the most primitive mullet had undergone the least amount of specialization. Such a mullet should retain largely unmodified teeth in bands on jaws, vomer, and palatines. The

anterior edge of the preorbital bone would be straight, and the maxillary and premaxillary with nearly straight contour would extend in line with the straight preorbital edge. The lips would not be specialized with a thin edge or with modified teeth and papillae. Among the genera recognized herein, *Agonostomus* comes nearest to fitting the above group of characters and may be considered as nearest the ancestral stock of the family.

The accompanying figure 32 is presented to show in a graphic manner some of the probable structural relationships common to certain mugilid genera. *Joturus* with its projecting snout and broadly attached gill membranes may represent the most specialized genus, more or less in the general line of descent from an *Agonostomus*-like mullet.

Rhinomugil is an aberrant genus. The nasal openings are low on the side of the head, in line with the lower edge of the orbit. No other mullet appears to be closely related to this genus.

The remaining genera of mugilid fishes appear to have two general lines of specialization, which could have arisen from a mugilid stock not greatly unlike *Mugil* as defined in this preliminary revision. This genus has the straight front edge of the preorbital and nearly straight contour of maxillary and premaxillary in line with front edge of preorbital. The lower lip is thin but unmodified. The first line of specialization, as represented by *Chelon*, *Crenimugil*, and *Heteromugil*, has a concave front edge of preorbital with strongly bent premaxillary and maxillary bones posteriorly, usually exposed below the preorbital. The lips and teeth may or may not be specialized. The second line of specialization represents a group of genera, namely *Xenomugil*, *Neomyxus*, *Chaenomugil*, and probably *Cestraeus*, with lower lips folded downward with highly specialized teeth and lips. The extreme specialization in this group may be considered the fresh-water genus *Cestraeus*. This genus has the teeth specialized into lamellae on the external surface of the lower jaw.

All fresh-water genera of mullets have ctenoid scales and all marine genera of mullets have cycloid scales except *Chaenomugil*, which has ctenoid scales.

Genus CESTRAEUS Valenciennes

Cestraeus Valenciennes, *in* Cuvier and Valenciennes, Histoire naturelle des poissons, vol. 11, p. 157, pl. 315, 1836 (genotype, *Cestraeus plicatilis* Valenciennes) (Celebes).

Gonostomyxus MacDonald, Proc. Zool. Soc. London, 1869, No. 1, p. 39, pl. 1 (genotype, *Gonostomyxus loa-loa* MacDonald) (Rewa River, Na Vita Levu, Fiji Islands).

Aeschrichthys Macleay, Proc. Linn. Soc. New South Wales, vol. 8, p. 5, text figs., pl., 1883 (genotype, *Aeschrichthys goldiei* Macleay) (rivers of New Guinea).

The lips, teeth, preorbital bone, and jaws of the Mugilidae seem to have become differentiated more than other characters. This genus appears to have had its mouth structures more complicated and specialized than any other genus of mullets.

Cestraeus is characterized by the specialized lower jaw and by the thick lips on both jaws; the lower jaw is devoid of teeth; externally there occurs on each side of the mandible along the lateral edge a wide strip of transverse, very close-set, membranous lamellae; posteriorly the mandible ends in four bluntly rounded lobes, free posteriorly; the posterior end of the upper lip forms another pair of fleshy lobes; premaxillary with a row of setiform teeth, tips simple; tip of lower jaw without symphyseal knob; scales ctenoid; front edge of preorbital without concavity and scarcely or not serrated; maxillary and premaxillary not bent downward in line with front edge of preorbital, the former extending far behind the latter; nostrils in line with upper edge of orbit, close together, remote from groove behind upper lip; adipose eyelid absent; apparently no teeth on vomer, palatines or tongue; posterior edge of preorbital wide, serrated; margin of lower jaw acutely angular; gill membranes extending far forward not broadly joined across isthums.

The following collections were studied: U. S. N. M. No. 122819 from New Guinea; No. 137266 from Bouro Island, Dutch East Indies; and No. 137267 from the Philippines.

Genus JOTURUS Poey

Joturus Poey, Memorias sobre la historia natural de la Isla de Cuba, vol. 2, p. 263, pl. 18, figs. 4–5, 1860 (genotype, *Joturus pichardi* Poey) (Cuba).

Xenorhynchichthys Regan, Ann. Mag. Nat. Hist., ser. 8, vol. 2, p. 461, 1908 (genotype, *Xenorhynchichthys stipes* (Jordan and Gilbert)=*Joturus stipes* Jordan and Gilbert) (Río Bayano near Panama).

I have examined the type of *Joturus stipes* Jordan and Gilbert (U. S. N. M. No. 31010 from Panama) and refer it to this genus.

This genus is characterized by the very thick lips in both jaws, devoid of teeth in the lips, and with the fleshy snout projecting beyond the lips so that the mouth is somewhat inferior in position, nearly horizontal; behind upper lip on upper jaw occurs a band of incisorlike multicuspid teeth, each side of lower jaw with a patch of similar multicuspid teeth widely separated at symphysis; no symphyseal knob on lower jaw; scales ctenoid; the front edge of the preorbital is nearly straight without concavity and not serrated; maxillary and premaxillary not bent downward posteriorly, but in line with front edge of preorbital; the nostrils are in line with upper edge of orbit, very close together, remote from front of snout; adipose eyelid absent; teeth present on vomer, palatines, and on tongue in small patches; posterior end of preorbital ending in a point ventrally; margin of

lower jaw rounded; gill membranes somewhat broadly attached across isthmus.

The following collections were studied: U. S. N. M. Nos. 45532 and 130878 from Mexico; Nos. 78887–9 from Panama; and No. 19915 from Central America.

Genus RHINOMUGIL Gill

Rhinomugil Gill, Proc. Acad. Nat. Sci. Philadelphia, 1863, p. 169 (genotype, *Mugil corsula* Hamilton-Buchanan) (rivers Ganges and Bengal).

Squalomugil Ogilby, Ann. Queensland Mus., pt. 1, pp. 3, 28, 1908 (genotype, *Mugil nasutus* de Vis) (coast of Queensland).

This genus is characterized by the thin lower lips, directed horizontally forward, not curved downward, and supplied with ciliform teeth embedded in the lip; upper lip with setiform teeth; tips of all teeth simple; tip of lower jaw with a symphyseal knob; scales ctenoid; front edge of preorbital nearly straight, without a conspicuous concavity and with but a few serrations; maxillary and premaxillary not strongly bent downward posteriorly but in line with front edge of preorbital; the nostrils are in line with the lower edge of the orbit, widely separated, and remote from tip of snout; adipose eyelid absent; vomer, palatines, and tongue probably toothless; posterior end of preorbital very narrow, ending in two or three spines; margin of lower jaw angular; gill membranes extending far forward, not joined across isthmus.

The diagnosis is based mostly on plate 9, figure 97, of Hamilton-Buchanan, and on Hora, Journ. Bombay Nat. Hist. Soc., vol. 40, No. 1, pp. 62–68, pl. and 3 text figs. of *Mugil corsula*, 1938; also on Whitley's (Australian Zool., vol. 10, No. 1, p. 22, fig. 16, 1941) account and description of *Mugil nasutus*, along with one specimen of *R. corsula*, U. S. N. M. No. 44767 from Rangoon.

Genus AGONOSTOMUS Bennett

Agonostomus Bennett, Proc. Comm. Sci. Corresp. Zool. Soc. London, No. 14, p. 166, 1832 (genotype, *Agonostomus telfairii* Bennett) (Mauritius).

Nestis Valenciennes, *in* Cuvier and Valenciennes, Histoire naturelle des poissons, vol. 11, p. 167, pl. 317, 1836 (genotype, *Nestis cyprinoides* Valenciennes) (Île de France; Bourbon).

Dajaus Valenciennes, *in* Cuvier and Valenciennes, *ibid.*, p. 164, pl. 316 (genotype, *Dajaus monticola* Valenciennes=*Mugil monticola* Griffith) (rivers of Dominican Republic, Puerto Rico, and Jamaica).

Neomugil Vaillant, Bull. Soc. Philom. Paris, ser. 3, vol. 6, p. 72,1894 (genotype, *Mugil digueii* Vaillant=*Mugil monticola* Griffith) (Lower California).

Agonostomus bryanti Bean and Weed (U. S. N. M. No. 72582) belongs to the Eleotridae, and probably in the genus *Hypseleotris* Gill. It is not a mullet.

This genus is characterized by the thick lips in both jaws and by a wide band of small teeth in both jaws; the outer rows of the upper

jaw have simple tips, but the inner rows of teeth have bifid or trifid tips, at least in the adults; the teeth in the lower jaw usually have simple tips, but occasionally some have bifid tips; no symphyseal knob on lower jaw; scales ctenoid; front edge of preorbital, serrated but without conspicuous concavity, nearly straight; maxillary and premaxillary not bent downward posteriorly but mostly in line with front edge of preorbital; nostrils in line with upper edge of orbit, very close together, remote from groove behind upper lip; adipose eyelid absent; villiform teeth on vomer and palatines but apparently absent on tongue; posterior edge preorbital very wide; margin of lower jaw rounded; gill membranes extending far forward not broadly connected across isthmus.

The generic diagnosis is based on the description by Fontaine entitled, "Sur La Chitte (*Agonostoma telfairii* Günther)" in Bull. Soc. Zool. France, vol. 53, pp. 386–390, figs. 1–4, 1928, and on collections in the National Museum, too numerous to list the numbers here, but from Guadaloupe Islands, Secas Island, Mexico, Panama, Venezuela, and West Indies (largely from Old Providence Island, Jamaica, Cuba, Puerto Rico, and Haiti). There are a few specimens from New Zealand and New South Wales and one from the Hawaiian Islands.

Genus CHAENOMUGIL Gill

Chaenomugil Gill, Proc. Acad. Nat. Sci. Philadelphia, 1863, p. 169 (genotype, *Mugil proboscidens* Günther) (west coast of Central America).

This genus is characterized by the broad, thick, pliable lips bearing externally a band of small teeth with bifid tips in several close-set rows on both upper and lower jaws; lower lip directed downward and fitting snugly behind the upper lip when mouth is closed; tip of lower jaw more or less bluntly pointed but symphyseal knob undeveloped; scales ctenoid; front edge of preorbital flexible without concavity, serrated only posteriorly; maxillary and premaxillary not bent downward posteriorly; nostrils in line with uppr edge of orbit, very close together, remote from groove behind broad upper lip; adipose eyelid absent; no teeth on vomer or palatines but some on tongue; posterior edge of preorbital wide, serrated; margin of lower jaw acutely angular; gill membranes extending far forward, not broadly connected across isthmus.

I have studied the following collections of *C. proboscidens:* U. S. N. M. Nos. 46563–4 and 125343 from Clarion Island; Nos. 54541, 56343, 67578, and 107050 from Socorro Island; No. 65449 from Chatham Island; No. 65448 from Culebra Island; No. 128504 from the Pearl Islands; No. 47471 from Mazatlán; No. 101645 from Cupica Bay, Colombia; and Nos. 79778–81, 79789, 79829, 79830, and 128571–2 from Panama. All records from the Pacific.

715201—46——2

Genus NEOMYXUS Steindachner

Neomyxus Steindachner, Ichthyologische Beiträge (VII), Sitz. Akad. Wiss. Wien, vol. 78, p. 384, 1878 (genotype, *Myxus* (*Neomyxus*) *sclateri* Steindachner) (Kingsmill and Sandwich Islands).

This genus is characterized by the thick pliable lips bearing externally two or three rows of characteristically shaped, 3-pointed or trifid setiform teeth on both jaws; lower lip with teeth and folded downward and fitting snugly behind the upper lip when mouth is closed; tip of lower jaw bluntly pointed with symphyseal knob small and located internally; scales cycloid; front edge of preorbital straight without convacity, serrated anteriorly; maxillary and premaxillary not bent downward posteriorly; nostrils in line with upper edge of orbit, moderately close together, the anterior nostril remote from groove behind upper lip; adipose eyelid absent; no teeth on vomer or palatines but probably some on the tongue; posterior edge of preorbital wide, and serrated; margin of lower jaw acutely angular; gill membranes extending far forward, not broadly connected across the isthmus.

I have studied the following collections in the United States National Museum: Niuafau Island, U. S. N. M. Nos. 91854–6, 91858–9, and 91983; Phoenix Islands, Nos. 115629 and 115632; Swains Island, Nos. 115627–8 and 115631; Wake Island, No. 82893; Makemo Island, No. 65969; Baker Island, No. 88153; Guam Island, No. 65968; Ellis Island, No. 65967; Tongareva Island, No. 88152; Manga Riva Island, No. 65596; Marquesas Islands, Nos. 89744–5; Hawaiian Islands, Nos. 52772, 55433, 55434, 55439, 55475, 55488, 55525, 82867, 89532, 115630, and 126540. These specimens all came from the central tropical Pacific Ocean or Oceania.

XENOMUGIL, new genus

Genotype.—Mugil thoburni Jordan and Starks, *in* Jordan and Evermann, U. S. Nat. Mus. Bull. 47, pt. 1, p. 812, 1896 (types, U. S. N. M. No. 47576, Galápagos Islands).

This genus is characterized by thick lips in both jaws, each bearing, externally, a uniserial row or in two rows anteriorly of setiform teeth with unbranched tips; lower lip folded downward and fitting snugly behind the upper lip when mouth is closed; tip of lower jaw bluntly pointed, with a small symphyseal knob somewhat developed behind tip of jaw; scales cycloid; front edge of preorbital straight without concavity and serrated; maxillary and premaxillary not bent downward posteriorly; nostrils in line with upper edge of orbit widely separated, the anterior one as close to groove behind upper lip as to posterior nostril; adipose eyelid present, well developed on adult; no teeth on vomer or palatines but probably a few on the tongue; pos-

terior edge of preorbital rather narrow, serrated; margin of lower jaw acutely angular; gill membranes extending far forward not broadly connected across the isthmus.

I have examined the following collections, all taken from the Galápagos Islands: U. S. N. M. Nos. 41381, 41459, 50017, 65597, 89748. The two types bear U. S. N. M. No. 47576.

This new genus may be distinguished from all other genera in the family Mugilidae by the key on pages 379 to 381.

Named *Xenomugil* in reference to the "strange" teeth and lips.

CRENIMUGIL, new genus

Genotype.—Mugil crenilabis Fôrskal.

Under *Chelon*, Oshima (Ann. Carnegie Mus., vol. 13, p. 257, pl. 13, fig. 1, 1922) lists a single species, "*Chelon crenilabis* (Fôrskal)," from the Pescadores Islands, west of Formosa, but since this species belongs in a genus distinct from *Chelon* Röse, with *Mugil chelo* as the type, it appears necessary to propose a new generic name for this type of mullet. It is diagnosed below.

This genus is characterized by the thick lips bearing papillae externally and internally; those forming the row along the external edge of the lips are crenulate, becoming more so in the adults and even continuous around the corners of the mouth; the thick lower lip is somewhat folded outward; the papillae apparently represent "teeth"; inside of upper jaw near front of mouth are plicate fleshy folds; symphyseal knob at tip of lower jaw; scales cycloid; front edge of preorbital with concave notch to receive corner of mouth; maxillary and premaxillary moderately bent downward, but the maxillary not exposed as in *Chelon;* nostrils on level of upper edge of orbit, moderately separated, so that the anterior nostril is as close to groove behind upper lip as to posterior nostril, the anterior nostril being rather close to the groove; no adipose eyelid; no teeth on vomer but teeth on palatines and a few on tongue; posterior edge of preorbital very wide, wider than space between nostrils; margin of lower jaw broadly angular; gill membranes extending far forward, not broadly connected across the isthmus.

I have examined the following collections bearing U. S. N. M. numbers: Indian Ocean, Nos. 44522 and 44557; Christmas Island, No. 19248; Phoenix Islands, Nos. 115640–2; Samoan Islands, No. 115639; Tahiti, No. 87649; Marshall Islands, No. 65912; Guam, No. 65913.

This new genus may be distinguished from all other genera in the family Mugilidae by the key on pages 379 to 381.

Named *Crenimugil* in reference to the crenulate lips.

Genus MUGIL Linnaeus

FIGURE 28, *a–c*

Mugil LINNAEUS, Systema naturae, ed. 10, vol. 1, p. 316, 1758 (genotype, *Mugil cephalus* Linnaeus) (European Ocean).

Cephalus LACEPÉDE, Histoire naturelle des poissons, vol. 2, p. 589, 1800, new name on Plumier MS. (genotype, *Mugil cephalus* Linnaeus).

Arnion GISTEL, Naturgeschichte des Thierreichs, p. x, 1848, substitute name for *Mugil* (genotype, *Mugil cephalus* Linnaeus).

Ello GISTEL, Handbuch der Naturgeschichte für alle Stände, p. 356, 1850[=1847], and Naturgeschichte des Thierreichs, p. 109, 1848; according to Whitley, Austral. Zool., vol. 6, pt. 3, p. 251, 1930, a synonym of *Mugil* Linnaeus.

Querimana JORDAN and GILBERT, Proc. U. S. Nat. Mus., vol. 5, p. 588, 1883 (genotype, *Myxus harengus* Günther) (Pacific coast of Central America).

The diagnosis of *Mugil* is based on descriptions by Cuvier and Valenciennes (Histoire naturelle des poissons, vol. 11, p. 19, pl. 307, 1836, Mediterranean Sea) and Günther (Catalogue of the fishes in the British Museum, vol. 3, p. 417, 1861, Mediterranean Sea), on

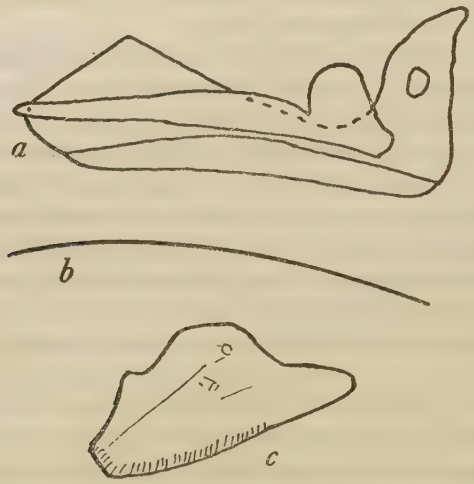


FIGURE 28.—Sketch of the maxillary, premaxillary, and preorbital bones of *Mugil cephalus* (U. S. N. M. No. 45009 from Greece): *a*, Maxillary lying over premaxillary; *b*, view of ventral contour of maxillary; *c*, preorbital.

U.S.N.M. Nos. 45009 and 84585 from the Mediterranean Sea, and on numerous other specimens referable to one or more species from many localities throughout the seas of the world.

I have examined the five types of *Mugil cetosus* Gilbert (U.S.N.M. Nos. 46554 and 48254) and a paratype (No. 124990) from Clarion Island and refer them to this genus. Eight small types of *Querimana gyrans* Jordan and Gilbert (U.S.N.M. No. 34966) belong to this genus.

This genus is characterized by a thin-edged lower lip projecting forward horizontally, not curved or folded downward; the teeth in the lower lip are setiform or ciliform, partly embedded or conspicuous; teeth in upper lip similar. The outer row of teeth in both lips is usually more prominent, with simple tips, and if inner rows occur these are either bifid or trifid, at least on adults (apparently the teeth in certain species of this genus become bifid or even trifid in large adults); a symphyseal knob present at tip of lower jaw; scales cycloid; the preorbital has the front edge straight or nearly so without a conspicuous concavity; maxillary and premaxillary not bent downward posteriorly, but in line with the front edge of preorbital; nostrils in line with the upper edge of the orbit, widely spaced, the anterior is closer to groove behind upper lip than to posterior nostril; adipose eyelid present; upper lip usually not so wide as distance between nostrils; teeth probably absent on vomer, palatines, and tongue; posterior edge of preorbital narrower than space between nostrils; margin of lower jaw angular; gill membranes extending far forward, not broadly connected across isthmus.

In this genus I find that in small specimens of certain species the teeth have simple tips, but later the inner teeth have bifid tips and in the largest adults some possess trifid tips. The teeth of the outer row usually have simple tips, but in some large specimens these are bifid too.

I have examined too many collections of the numerous species referable to this genus to list them here. The localities represented are: Europe, both coasts of Africa, both coasts of North and South America, West Indies, Hawaiian Islands, Australia, Oceania, Japan, coast of Asia, in temperate and tropical seas.

Genus MYXUS Günther

FIGURE 29, *a–c*

Myxus GÜNTHER, Catalogue of the fishes in the British Museum, vol. 3, pp. 409, 466, 1861 (genotype, *Mugil elongatus* Günther) (Hobsons Bay and Port Jackson, Australia).

This genus is characterized by a moderately thin lower lip projecting horizontally forward, with a single row of small, close-set, incisorlike teeth rather firmly set; teeth in upper jaw similar and in one row; all teeth with simple tips; no inner rows of teeth in either jaw; a symphyseal knob at inside tip of lower jaw; scales cycloid; front edge of preorbital straight, no concave notch; maxillary and premaxillary not bent downward but nearly straight, in line with front edge of preorbital; maxillary not exposed posteriorly; nostrils on level of upper edge of orbit rather close together, the anterior much farther from groove behind upper lip than from posterior nostril; no adipose eyelid; narrow band of teeth on vomer and palatines, and probably on tongue;

posterior edge of preorbital very wide, much wider than space between nostrils; margin of lower jaw rounded; gill membranes extending far forward, not broadly connected across isthmus.

The diagnosis of this genus was based on *M. elongatus*, U. S. N. M. Nos. 47770 and 47773 from Lord Howe Island and Nos. 59889, 59913, and 83052 from New South Wales.

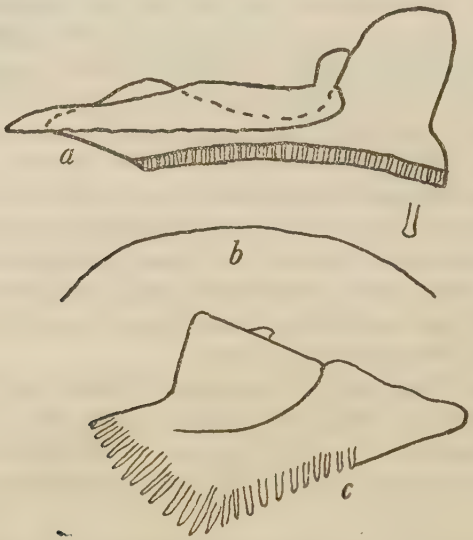


FIGURE 29.—Sketches of the maxillary, premaxillary, and preorbital bones of *Myxus elongatus* (U. S. N. M. No. 59912 from New South Wales): *a*, Maxillary lying over premaxillary (a tooth is shown below at right hand side); *b*, view of ventral contour of maxillary; *c*, preorbital.

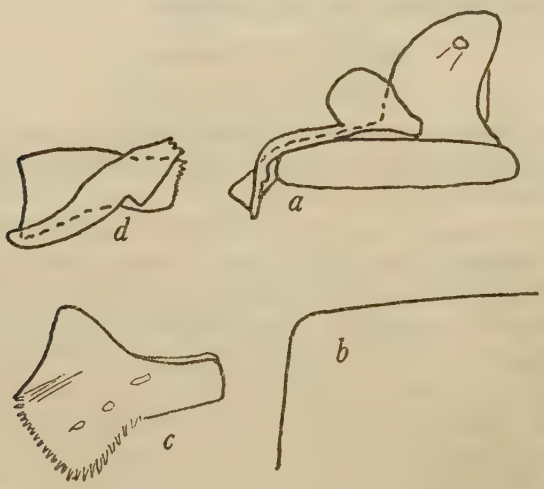


FIGURE 30.—Sketches of the maxillary, premaxillary, and preorbital bones of *Chelon chelo* (U. S. N. M. No. 123002 from Europe): *a*, Maxillary lying over premaxillary; *b*, view of ventral contour of maxillary; *c*, preorbital; *d*, posterior tips of maxillary and premaxillary.

Genus CHELON Röse

FIGURE 30, *a–d*

Chelon RÖSE, Petri Artedi Angermania—Sueci synonymia nominum piscium . . . , ed. 2, p. 118, 1793.—JORDAN and EVERMANN, Genera of fishes, pt. 1, p. 52, 1917 (genotype, *Mugil chelo* Cuvier and Valenciennes).

Liza JORDAN and SWAIN, Proc. U. S. Nat. Mus., vol. 7, pp. 261, 262, 1884 (genotype, *Mugil capito* Cuvier) (Mediterranean and seas of Europe).

Oedalechilus FOWLER, Proc. Acad. Nat. Sci. Philadelphia, vol. 55, p. 748, 1903 (genotype, *Mugil labeo* Cuvier) (Mediterranean Sea).

Ellochelon WHITLEY, Australian Zool., vol. 6, pt. 3, p. 251, 1930 (genotype, *Mugil vaigiensis* Quoy and Gaimard) (Waigiou).

The genus *Oedalechilus* Fowler, with *Mugil labeo* Cuvier as its type, appears to represent the most extreme development of the mouth of the genus *Chelon*. In *M. labeo* the upper lip is nearly as broad as the orbit and the maxillary bone extends vertically downward below the preorbital bone where its posterior end is exposed. There are other species from the Mediterranean in which the upper lip is not so broad and the mouth is more horizontal with the maxillary similarly exposed.

Chelon Röse (loc. cit.) was listed by Jordan and Evermann (loc. cit.) as a valid genus, with "*Chelon* of Gesner, which is probably *Mugil chelo* Cuvier and Valenciennes" as its type. Although the generic name is given as *Chelon* by Röse, no species are listed in the binomial sense, and no description of any kind is given, yet the genera listed in the 1793 edition are definitely used in the binary sense, including *Chelon*. Common names of pre-Linnaean authors with references are cited in the synonymy, as for example: "Labeo. Gaz. Arist. l. c." and "chelo. Rondel. l. 9 c. 5, p. 266. gesner. p. 552." The mullet "*Chelo*" or "*Chelon*" of the Mediterranean Sea is such a well-known species that Günther (Catalogue of the fishes in the British Museum, vol. 3, p. 454, 1861) in the synonymy under *Mugil chelo* lists without question the common name "Chelon" as used by "Rondel.," "Gesner," "Willughby," and "Ray" but does not mention Röse. The first description and binomial use of *Mugil chelo* appears to be that by Cuvier (in his Règne Animal).

Oshima (Ann. Carnegie Mus., vol. 13, pp. 241, 257, pl. 13, fig. 1, 1922) has recognized the genus *Chelon* Röse, 1793, listing but one species, *Chelon crenilabis* (Fôrskal) under the genus, but this species has most elaborately developed papillate lips and otherwise is not a *Chelon* but belongs in a new genus herein proposed on page 387.

I have examined the small type of *Agonostomus dorsalis* Streets from the Samoan Islands (U. S. N. M. No. 15111) and refer it to this genus. Two paratypes of *Mugil canaliculatus* J. L. B. Smith (U. S. N. M. No. 93647) from Durban, South Africa, also belong to this genus.

The genus *Chelon* Röse is characterized by the thin-edged lower lip projecting forward horizontally, not curved or folded downward; the lower lip is made up of ciliform teeth embedded in the lip, none of which project beyond the flesh of the lip; in the upper lip the setiform teeth project beyond the lip; tips of all teeth simple, none bifid or trifid even in large adults; behind outer row of setiform teeth in upper lip occur minute teeth in one or more rows, all with simple tips; a symphyseal knob at tip of lower jaw; scales cycloid; the preorbital has a concave notch or shallow concavity in its front margin to accommodate the exposed maxillary, which is hooked or bent downward; the premaxillary is also bent posteriorly at a more or less sharp angle, the posterior part of this bone lying behind the maxillary; the nostrils are on the level of the upper edge of the orbit and are close together, usually closer to each other than anterior is from groove behind upper lip; no adipose eyelid present; upper lip wider than distance between nostrils; teeth on vomer, palatines, and tongue present or absent; the posterior edge of the preorbital is wider than the space between the nostrils; margin of lower jaw angular; gill membranes extending far forward, not broadly connected across isthmus.

The collections referred to this genus are too numerous in the National Museum to list here, but they came from the following localities in the Pacific: Marquesas Islands, Phoenix Islands, New Hebrides, Sumatra, Java, Roual, Samoan Islands, Tahiti, New Guinea, Christmas Island, Marshall Islands, Solomon Islands, Celebes, and Philippine Islands, China coast, Japan, Korea, Peter the Great Bay, and New South Wales, Australia. In the Atlantic: Europe, British Isles, Norway, Azores, and Canary Islands. Other localities: Mediterranean Sea, Island of Mauritius, Burma and India, British East Africa, British South Africa, and French Congo, Africa.

I did not find any specimen from the New World that was referable to this apparently Old World genus.

Genus TRACHYSTOMA Ogilby

FIGURE 31, *a–c*

Trachystoma OGILBY, Proc. Zool. Soc. London, 1887, p. 614 (genotype, *Trachystoma multidens* Ogilby) (Port Stevens at mouth of Keruah River) (=*Mugil breviceps* Steindachner=*Mugil petardi* Castelnau).

Sicamugil FOWLER, Not. Nat., No. 17, p. 9, fig. 1, 1939 (genotype, *Mugil hamiltoni* Day) (fresh waters of Burma).

Gracilimugil WHITLEY, Australian Zool., vol. 10, pt. 1, p. 19, fig. 14, 1941 (genotype, *Gracilimugil ramsayi* (Macleay)=*Mugil ramsayi* Macleay, 1883) (Burdekin River, Queensland).

Although I have not seen a specimen of *Gracilimugil ramsayi* (Macleay) I am unable to find any statement in Whitley's diagnosis that definitely separates it from *Trachystoma*.

This genus is characterized by having ciliform teeth embedded in the lips of both jaws, their tips not or scarcely visible; the lower lip is thin as in *Chelon* and directed forward horizontally; tip of lower jaw with symphyseal knob; scales ctenoid; front edge of preorbital nearly straight, without conspicuous concave notch, and its posterior edge with or without greatly enlarged spines; maxillary and premaxillary not bent downward but extending in nearly same line as front edge of preorbital except when the spines project as in *hamiltoni* Day; nostrils in line with upper edge of orbit, somewhat separated, closer together than anterior is from edge of groove behind upper lip or as far apart as anterior is from edge of groove behind upper lip; adipose eyelid wholly absent; a narrow band of teeth on vomer and palatines and

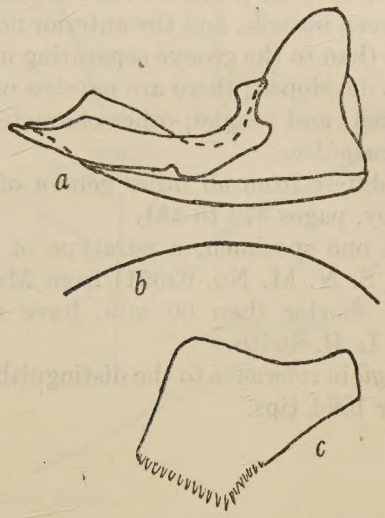


FIGURE 31.—Sketches of the maxillary, premaxillary, and preorbital bones of *Trachystoma petardi* (U. S. N. M. No. 59866 from New South Wales): *a*, Maxillary lying over premaxillary; *b*, view of ventral contour of maxillary; *c*, preorbital.

probably on tongue; margin of lower jaw rounded to somewhat angular; gill membranes extending far forward, not broadly connected across isthmus; anal origin notably in front of second dorsal origin.

The generic diagnosis was based on three specimens of *Trachystoma petardi* (U. S. N. M. No. 59866) from Clarence River, New South Wales. Also I refer to this genus a specimen from Durban, South Africa, sent to the National Museum many years ago under the name "*Mugil euronotus*" by the Albany Museum. This specimen agrees with Dr. J. L. B. Smith's description (Ann. South African Mus., vol. 30, pp. 610, 613, fig. 7, pl. 16, E, 1935), which states that it occurs almost wholly in fresh water and only rarely in the sea. I have studied a small specimen of *Mugil hamiltoni* Day (U. S. N. M. No.

44795) from Rangoon that I refer to this genus. From *petardi* it differs in the greater development of the preorbital spines.

HETEROMUGIL, new genus

Genotype.—Mugil tricuspidens J. L. B. Smith.

This new genus of Mugilidae is a *Chelon* with trifid and rarely bifid teeth in the upper lip in a single row, as observed on specimens 60 mm. and longer. These teeth are setiform, incisorlike, and close-set. The lower lip is moderately thin with embedded ciliform teeth. It has the maxillary exposed beyond and below the preorbital; the premaxillary is sharply angular, extending behind the maxillary bone which turns downward; the upper lip is thick and wide, wider than the distance between nostrils; the posterior edge of the preorbital is wider than the space between nostrils, and the anterior nostril is much closer to the posterior one than to the groove separating upper lip and snout; no adipose eyelid is developed; there are patches of villiform teeth on the pterygoids, vomer, and tongue; other characters are those of the genotype *Mugil tricuspidens*.

This new genus differs from all other genera of Mugilidae as distinguished in the key, pages 379 to 381.

I have examined one specimen, a paratype of *Mugil tricuspidens* J. L. B. Smith (U. S. N. M. No. 93651) from Mazeppa Bay, South Africa. Specimens shorter than 60 mm. have not been collected according to Dr. J. L. B. Smith.

Named *Heteromugil* in reference to the distinguishing (i. e., different) teeth, with trifid or bifid tips.

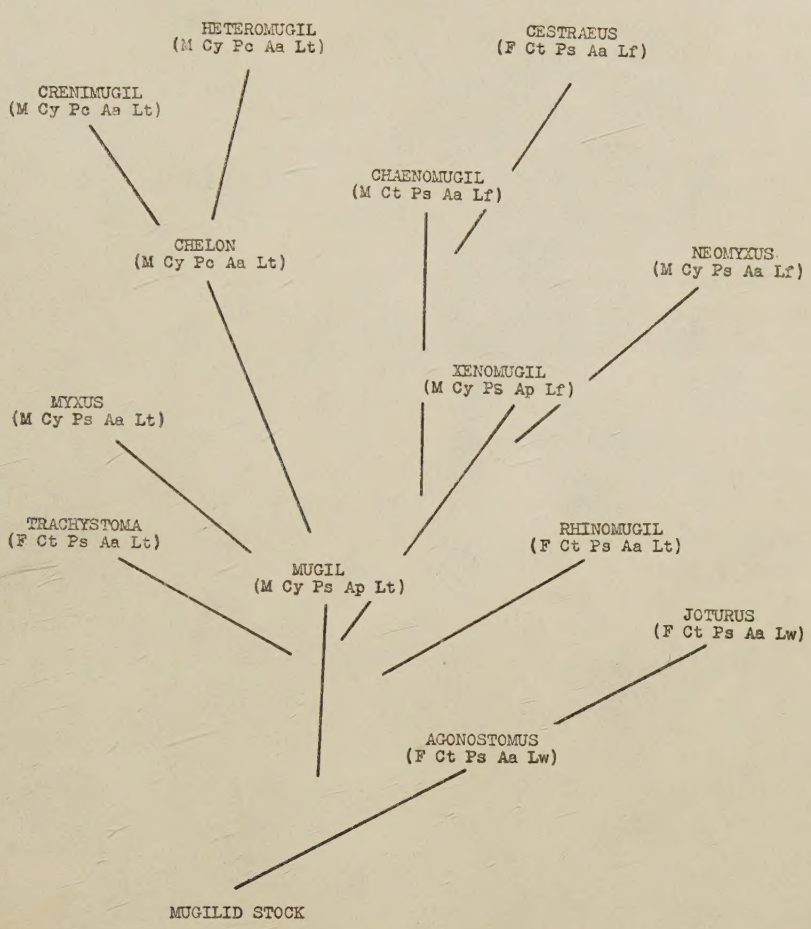
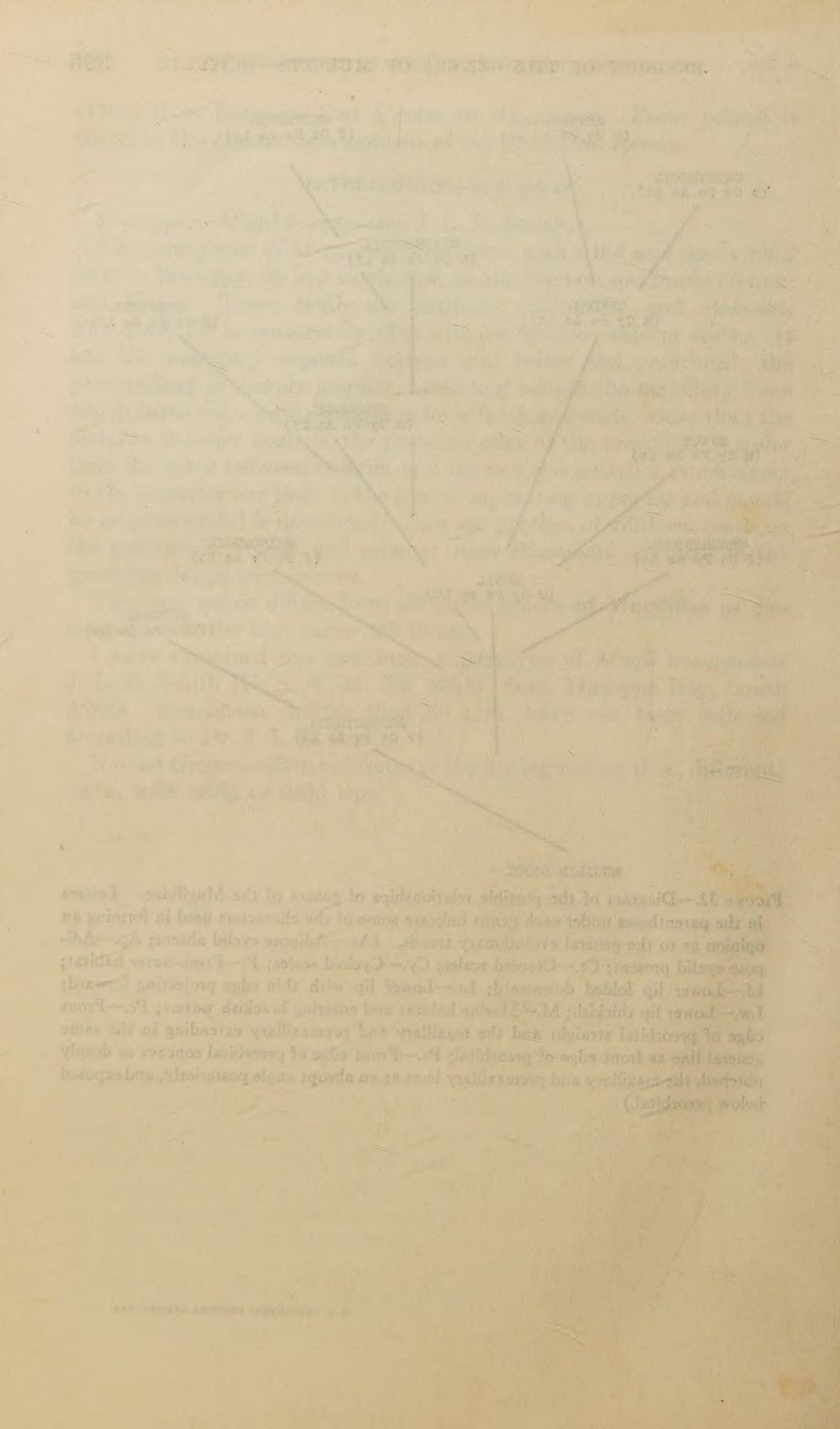


FIGURE 32.—Diagram of the possible relationships of genera of the Mugilidae. Letters in the parentheses under each genus indicate some of the characters used in forming an opinion as to the general evolutionary trends. (Aa.—Adipose eyelid absent; Ap.—Adipose eyelid present; Ct.—Ctenoid scales; Cy.—Cycloid scales; F.—Fresh-water habitat; Lf.—Lower lip folded downward; Lt.—Lower lip with thin edge projecting forward; Lw.—Lower lip thickish; M.—Marine habitat and entering brackish waters; Pc.—Front edge of preorbital straight and the maxillary and premaxillary extending in the same general line as front edge of preorbital; Ps.—Front edge of preorbital concave or deeply notched, the maxillary and premaxillary bent at an abrupt angle posteriorly, and exposed below preorbital.)

U. S. GOVERNMENT PRINTING OFFICE: 1946